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(71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindoven (NL).

(71) Applicant *(for SE only)*: PHILIPS NORDEN AB [SE/SE]; Kottbygatan 7, Kista, S-164 85 Stockholm (SE).

(72) Inventors: CHOW, Hui-Meng; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). AZEVEDO, Jose; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). McGEE, Susan; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) Agent: EVERS, Johannes, H., M.; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).

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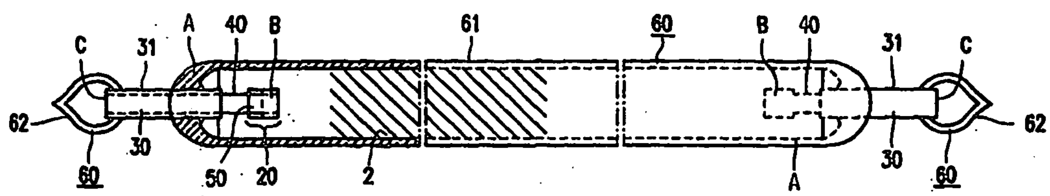

(57) Abstract

A low-pressure discharge lamp of the invention comprises a tubular glass lamp vessel (60) which is closed in a vacuum-tight manner. The lamp vessel contains an ionisable filling comprising a rare gas in the lamp vessel. Electrodes (20) are arranged in the lamp vessel which are provided with an electron emitter (50). Current conductors (30) are connected to the electrodes (20). These have a surface (31) outside the lamp vessel. At least one of the electrodes (20) is a mesh body and the electron emitter (50) comprises at least one mixed oxide of at least one of the elements Ba and Sr with at least one metal from the group comprising Ta, Ti, Zr, Sc, Y, La and the lanthanids, wherein electron emitters of the composition $Ba_xSr_{1-x}Y_2O_4$, x being in the range of 0 to 1, are excluded. The mesh body allows for a faster attainment of the operating temperature than an electrode body of solid material. This reduces sputtering.

Low-pressure discharge lamp.

The invention relates to a low-pressure discharge lamp, comprising
a tubular glass lamp vessel which is closed in a vacuumtight manner;
an ionizable filling comprising a rare gas in the lamp vessel;
electrodes in the lamp vessel which are provided with an electron emitter;
current conductors connected to the electrodes and having a surface outside the lamp vessel.

Such a low-pressure discharge lamp is known from EP-A 0 562 679 (PHN 14.189).

The known lamp is of a simple construction which is easy to realise. The lamp vessel has a tubular main part and spherical auxiliary parts at both sides which are connected to the main part by metal tubes. These metal tubes serve as current conductors. End portions thereof protruding inside the main part of the discharge vessel form electrodes. When manufacturing the lamp, the lamp vessel can be cleaned and be provided with its filling, through the metal tubes. The auxiliary parts can be obtained by fusing a glass tube to each of the metal tubes and subsequently closing the glass tubes free ends, for example by fusion.

The construction of the known lamp renders it easy to realise lamps of a comparatively small internal diameter, for example 1.5 to 7 mm, and of a comparatively great length of, for example, 1 m or more.

The ionizable filling may comprise a rare gas or a mixture of rare gases, or in addition a component capable of evaporation such as, for example, mercury. The lamp vessel wall may be provided with a fluorescent material. The lamp may be used for lighting purposes, or as a signal lamp, for example with a neon filling as a tail lamp or stop lamp in vehicles. In the latter application the lamp has the advantage over an incandescent lamp that it emits its full light after 10 ms already, instead of 300 ms after being energized.

The high cathode fall ($\approx$ 180 volts) and high work function of axially configured, emitterless and hollow electrodes typically used in the known lamp limit their use

to relatively low lamp currents. Lower current results in a low light output (< 900 lm/m) and the high cathode fall reduces the lamp efficacy. High current narrow diameter (ND) fluorescent and neon lamps are highly desirable yet are non-existent. The requirement for such lamps, among others, is a low cathode fall of, for example, less than 80 volts. There is therefore a need in the art for high current and high efficacy ND lamps. Such higher current ND fluorescent lamps may be used in automobile interior lighting or as backlights in laptop computers.

The cathode fall of an electrode in a lamp can be reduced by promoting electron emission. In traditional larger diameter and high current (>200 mA) fluorescent lamps, a tungsten coil coated with triple carbonates (for example a mixture of barium, strontium and calcium carbonates) is used as the electrode. Consequently, these lamps have four terminals, two for each electrode on either side. During lamp manufacturing, in an extra process step, the carbonates are thermally converted into oxides in the lamp by passing a current through the tungsten coil. In the lamp, these oxides [(Ba,Sr,Ca)O] promote electron emission via thermionic emission when the electrode is heated to 1000-1300°C, either by passing a heating current through the tungsten coil or by ion-bombardment. It would be desirable to have novel electrodes which do not require the extra thermal in-lamp processing step during manufacture, particularly since this step requires expensive processing time.

An ND lamp requires single-lead electrodes because of geometrical constraints and therefore ion-bombardment is the only source of cathode heating. Due to the absence of a coil the use of carbonates in single-lead ND lamps would require external RF heating to convert them to oxides during manufacturing. This adds an additional, even more costly step to the manufacturing process.

It is an object of the present invention to provide a low-pressure discharge lamp of the kind described in the opening paragraph which is capable of providing an increased luminous flux.

According to the invention, this object is realised in that at least one of the electrodes is a mesh body and in that the electron emitter comprises at least one mixed oxide of at least one of the elements Ba and Sr with at least one metal from the group comprising Ta, Ti, Zr, Sc, Y, La and the lanthanids, wherein electron emitters of the composition $Ba_xSr_{1-x}Y_2O_4$, x being in the range of 0 to 1, are excluded.

The non-prepublished Application IB 95/00951 (PHN 15023) describes a

narrow diameter lamp according to the above mentioned kind in which the electrodes are a mesh body. The mesh body may be covered with $Ba_xSr_{1-x}Y_2O_4$ as an emitter, wherein x is, for example, 0.75.

In the lamp according to the invention the electrode is formed by a mesh body carrying an electron emitter material. As compared to an electrode having a continuous wall, a mesh body of the same material and geometry has a significantly lower mass and therefore a significantly lower heat capacity. Such a mesh body will have a lower heat loss to its surroundings at a given temperature than a corresponding continuous walled electrode. Alternatively, for a given heat loss, the mesh body can be operated at a significantly higher temperature than an electrode having a continuous wall. The higher temperature promotes greater emission from the electron emitter material and leads to lower cathode fall. With a lower cathode fall, the lamp can have a higher lamp current and greater light output without increasing the temperature in the seal area of the lamp. An additional advantage of the mesh body is that it has the capability of reducing sputtering of metal from the electrode onto the wall of the lamp vessel and the consequent darkening of the inner wall of the lamp vessel. This is the result of faster heating of the tip portion of the mesh body to its operating temperature by ion bombardment during the ignition phase, due to the lower mass of the mesh body, providing faster glow-to-arc transition. Reduced sputtering can also be attributed to the capability of improved adhesion of the emitter material to the mesh body.

In a favorable embodiment, the mesh body is hollow and circular cylindrical and extends at least substantially parallel to the lamp axis. Such a shape is advantageous for narrow diameter lamps because within a narrow diameter the length can be selected to carry a sufficient quantity of emitter material. Such a shape is easy to form by rolling a length of the mesh material about a cylindrical jig, welding, and then cutting to length.

Preferably the electron emitter comprises one or more mixed oxides selected from the group consisting of $Ba_4Ta_2O_9$, $Ba_5Ta_4O_{15}$, BaY_2O_4, $BaCeO_3$, Ba_2TiO_4, $BaZrO_3$, $Ba_xSr_{1-x}TiO_3$, and $Ba_xSr_{1-x}ZrO_3$, wherein x ranges from a value of 0 to 1.

Most preferably the electron emitter comprises one or more mixed oxides selected from the group consisting of $Ba_4Ta_2O_9$, $BaCeO_3$, Ba_2TiO_4, $BaZrO_3$, $Ba_{.5}Sr_{.5}TiO_3$, and $Ba_{.5}Sr_{.5}ZrO_3$.

The lamp which has only one electrode provided with a mesh body is highly suitable for DC operation. The electrode with the mesh body is the cathode then. It is favourable, however, for example for AC operation, when both electrodes are fitted with

such a mesh body.

The mesh body may be fixed directly to a hollow cylindrical ferrule or other conductive element serving as the current conductor for the electrode. However, to further reduce heat transmission via the current conductor, an electrically conductive thermal isolator is preferably interposed between the current conductor and the mesh body. The thermal isolator may be a length of wire as in the above described embodiments. The wire may be mounted to the current conductor and to the mesh body with welds, for example with resistance welds or laser welds. Alternatively, the electrically conductive thermal isolator may comprise two or more wires. This embodiment may be preferable in lamps which are subjected to accelerations during operation, for example owing to shocks or vibrations. Alternatively, where a ferrule is used as the current conductor, the thermal isolator may be an integral elongate extension of the ferrule formed, for example, by removing material from the inwardly protruding end of the ferrule by cutting, grinding, sawing, etc.

The current conductor may be made of a metal which has a coefficient of expansion which corresponds to that of the glass of the lamp vessel, for example a CrNiFe alloy in the case of lime glass, for example Cr 6% by weight, Ni 42% by weight, and the rest Fe. For a hard-glass lamp vessel, for example of borosilicate glass, a current conductor may be used, for example made of Ni/Fe or NiCoFe, for example Ni 29% by weight, Co 17% by weight, the rest Fe, for example with a diameter of 1.5 mm and a wall thickness of 0.12 mm.

Alternatively, the current conductor may consist of, for example, CrNiFe with 18% Cr by weight, 10% Ni by weight, and the rest Fe, or of Ni. The electrically conducting thermal isolator may then be, for example, NiCr, for example Ni80Cr20 (weight/weight), for example in the form of wire of 0.125 or 0.250 mm diameter.

In an embodiment the current conductor is solid. The lamp vessel may be manufactured in a chamber proces. A favorable embodiment is characterised in that the current conductor connected to the mesh body is a tube and in that the lamp vessel has a main part and an auxiliary part which parts are connected to each other by the tube. In this embodiment the tube can be used to evacuate the lamp and to provide it with its filling, which renders the manufacturing proces more easy.

An attractive embdodiment is characterised in that the mesh body is arranged in the auxiliary part of the lamp vessel. This has the advantage that material detached from the mesh body during operation will end up substantially outside the main part of the lamp vessel, so that this part itself remains clear. The lumen output accordingly

remains high during lamp life. This embodiment is of particular importance for lamps whose filling comprises a component capable of evaporation. Since the discharge arc applies itself mainly to the mesh body during normal operation, the space outside the lamp vessel, where the mesh body is accommodated, assumes a comparatively high temperature. The evaporation component can thus have a comparatively high vapour pressure.

These and other aspects of the invention are discussed in more detail with respect to the drawing. Therein

Figure 1 shows schematically an embodiment of the low-pressure discharge lamp according to the invention;

Figure 2 shows a portion of the lamp of Figure 1 in more detail;

Figure 3 shows a corresponding portion of a second embodiment; and

Figure 4 shows a corresponding portion of a third embodiment.

With reference to Figure 1, the low-pressure discharge lamp has a tubular glass lamp vessel 60. The lamp vessel has a main part 61 and auxiliary parts 62. It has an ionizable filling comprising rare gas, such as for example argon or neon, or it may contain mercury vapor, depending on the lamp type. A luminescent layer 2 may cover the inner surface or at least a major portion thereof. The lamp vessel is made of glass which transmits the visible radiation generated in the luminescent layer 2. Current conductors in the form of tubes 30 enter the main part of the lamp vessel each at a respective end portion B and connect the main part to a respective auxiliary part. The current conductors 30 have a surface 31 outside the lampvessel.

A mesh body 20, shown in detail in Fig.2, has been laser or resistance welded onto the current conductor 30 with a thermal isolator, for example, a Ni or Ni-Cr wire 40. The mesh body 20 is coated with an electron emitter material 50 on at least one of its surfaces, and preferably on an internal surface.

The cylindrical mesh body 20 is easily formed by wrapping a mat of the mesh material around a rod and welding the opposing edges together, with or without overlap. A long mesh cylinder is easily formed which can be then be cut to obtain a protrusion, or electrode tip, 20 of the desired length. The mesh protrusion is then connected to the wire 40 via welding. The mesh body 20 is coated with emitter material by dipping the

mesh body in a suspension of the emitter material. This is most easily accomplished after the mesh body and wire 40 have been welded together. After the emitter has been dried, the other end of wire 40 is secured to the ferrule 30. The emitter material may also be applied to the screen by other methods, for example, by spraying.

In one implementation, 100 x 100 mesh material having an opening size of 0.14 mm and an open area of about 30% was rolled into a hollow tube, welded, and cut into 3 mm lengths. A NiCr wire was welded to the mesh body, and the mesh body was dip coated with emitter materials (eg. $Ba_4Ta_2O_9$) mixed with a binder (nitrocellulose) and an appropriate solvent (butyl acetate). The coated mesh was then heated to 1000°C to burn off the binder. For Ni and Mo mesh, the binder was burned off in He-H_2. While for Ta mesh, binder burnoff was carried out in Ar.

Figure 3 shows another embodiment, in which the thermal isolator 40 is an integral elongate extension of the ferrule 30 having a length "l" and a width "w" obtained by removing material from the ferrule 30, such as by sawing, grinding, etc.

In the above Figures, the hollow ferrule 30 serves both as a current conductor to connect the electrode to a source of electric potential outside of the lamp envelope and as a conduit to evacuate and fill the lamp vessel. Such a seal structure is useful for lamps having a narrow diameter, for example less than 5 mm. In lamps having a larger diameter, other seal structures are used, such as a lamp stem. With a lamp stem, a glass tube is used to evacuate and fill the lamp vessel, and the current conductor is in that case a wire. Figure 4 illustrates an embodiment of an electrode for a lamp having a lamp stem in which the mesh cylinder body is connected directly to a current conductor formed by a wire feed-through. The wire has an offset to maintain the mesh body aligned with the lamp axis.

The Table shows the cathode fall for a group of test lamps having the geometry described with respect to Figure 4 and having mesh material Ni, Mo or Ta. The lamps were fluorescent lamps with mercury, argon at 40 mbar and 40 ma current. The emitter material was $Ba_4Ta_2O_9$. The results include lamps operated continuously and lamps cycled on/off.

TABLE

Type of Mesh Material	Number of Lamps Tested	Cathode Fall, Volts (Average) 1 Hr.	100 Hrs.	820 Hrs.	1500 Hrs.
Ni	4	28.9	31.3	38.4	41.0
Mo	4	30.0	33.0	41.1	46.3
Ta	3	30.0	31.1	38.4	39.9

During operation, there was some blackening of the lamps but it was stable and not severe. The tests were discontinued after 1500 hours due to mercury depletion, not necessarily due to the use of the mesh material. The mesh form provided a better range of results that had a prior test with solid cup and electrode forms. Thus, the use of a mesh body as an electrode tip carrying emitter material serves as another tool for the lamp designer in immproving lamp performance in cold cathode lamps, and especially in narrow diameter lamps.

CLAIMS:

1. A low-pressure discharge lamp, comprising
a tubular glass lamp vessel (60) which is closed in a vacuumtight manner;
an ionizable filling comprising a rare gas in the lamp vessel;
electrodes (20) in the lamp vessel which are provided with an electron emitter (50);
current conductors (30) connected to the electrodes (20) and having a surface (31) outside the lamp vessel;
characterized in that,
at least one of the electrodes (20) is a mesh body and in that the electron emitter (50) comprises at least one mixed oxide of at least one of the elements Ba and Sr with at least one metal from the group comprising Ta, Ti, Zr, Sc, Y, La and the lanthanids, wherein electron emitters of the composition $Ba_xSr_{1-x}Y_2O_4$, x being in the range of 0 to 1, are excluded.

2. A lamp as claimed in Claim 1, wherein the electron emitter (50) comprises one or more mixed oxides selected from the group consisting of $Ba_4Ta_2O_9$, $Ba_5Ta_4O_{15}$, BaY_2O_4, $BaCeO_3$, Ba_2TiO_4, $BaZrO_3$, $Ba_xSr_{1-x}TiO_3$, and $Ba_xSr_{1-x}ZrO_3$, wherein x ranges from a value of 0 to 1.

3. A lamp as claimed in Claim 2, wherein the electron emitter (50) comprises one or more mixed oxides selected from the group consisting of $Ba_4Ta_2O_9$, $BaCeO_3$, Ba_2TiO_4, $BaZrO_3$, $Ba_{.5}Sr_{.5}TiO_3$, and $Ba_{.5}Sr_{.5}ZrO_3$.

4. A low-pressure discharge lamp as claimed in Claim 1, 2 or 3, characterized in that the current conductor (30) connected to the mesh body (20) is a tube and in that the lamp vessel (60) has a main part (61) and an auxiliary part (62), which parts are connected to each other by the tube.

5. A low pressure discharge lamp as claimed in Claim 4, characterised in that the mesh body (20) is arranged in the auxiliary part (62) of the lamp vessel (60).

6. A low-pressure discharge lamp as claimed in Claim 4 or 5, characterized in each of the electrodes (20) is a mesh body.

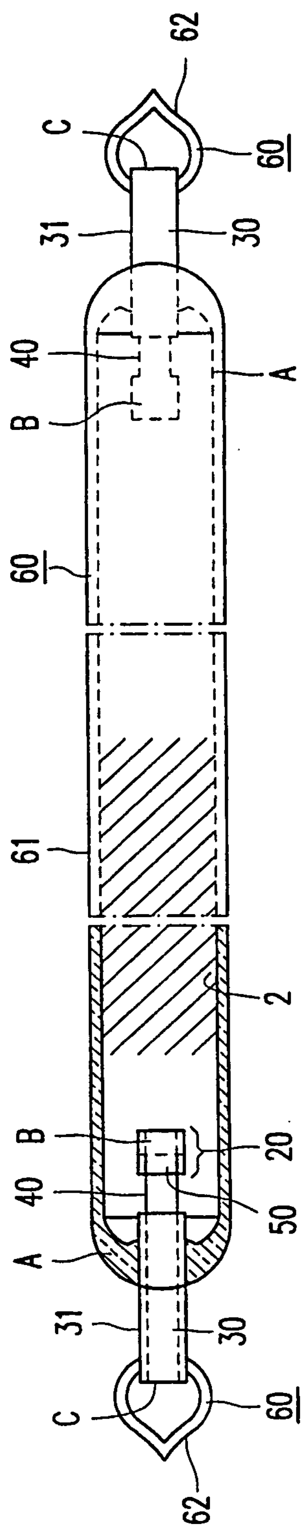

FIG. 1

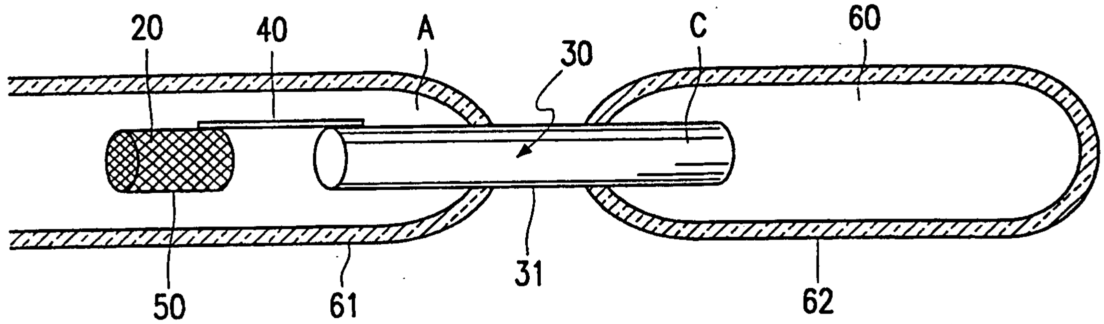

FIG. 2

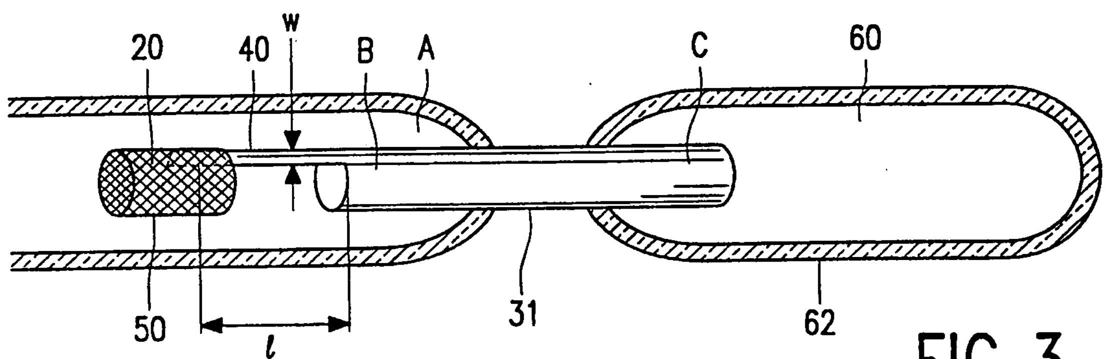

FIG. 3

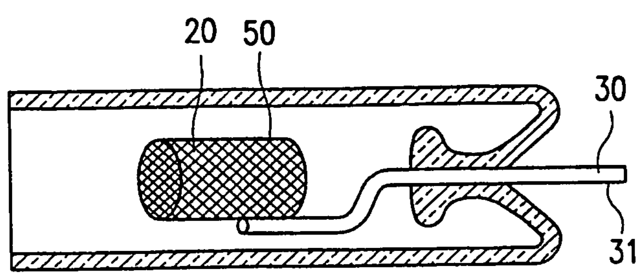

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/01344

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01J 61/067

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI,CLAIM

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4866339 A (A.B.BUDINGER ET AL), 12 Sept 1989 (12.09.89), column 2, line 22 - column 4, line 21, figure 1, abstract --	1-6
A	Patent Abstract of Japan, abstract of JP 7021976 A (TOSHIBA LIGHTING & TECHNOL CORP.), 24 January 1995 (24.01.95) --	1-6
A	US 4031426 A (E.R. KERN), 21 June 1977 (21.06.77), column 2, line 28 - column 3, line 20, figure 1 --	1-6

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. +46 8 666 02 86

Authorized officer
Karin Säfsten
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/01344

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/04/98

International application No.
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